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13. ABSTRACT (Maximum 200 words)

The transport properties of La-Ca manganites with the perovskite structure have been investigated over a wide range of temperatures above room temperature, and over the whole La-Ca concentration range. They can be understood in terms of a model proposed by Emin and Holstein in which the charge carriers are small polarons diffusing by adiabatic hops. For the first time it has been demonstrated that polaron hopping in the presence of strong on-site coulomb interaction results in Mott-Hubbard insulating behavior.

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FINAL REPORT

to the

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

for a program in

MODIFICATION OF HIGH T_c SUPERCONDUCTORS BY ION IMPLANTATION

for the period 6/30/94-9/29/97

under

AASERT GRANT F49620-94-1-0373

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October 1997

Final Report

MODIFICATION OF HIGH T_c SUPERCONDUCTORS BY ION IMPLANTATION

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The reported ability to introduce large concentrations of cations with good control over space and site occupancy into the superconducting cuprate perovskite family by ion implantation without causing undue damage to the structure was the basis for our initial work. However, further developments[1,2] showed that the perovskite structures were severely damaged by the large doping and that the results were due to miscalculation of the range of implant. As a result, the investigation was shifted to studies of the manganate perovskites which undergo an insulator-metal transition and show colossal magneto resistance when properly doped. Like the high Tc cuprates, these compounds are highly correlated and show unusual magnetic and transport data. When properly doped they order magnetically at temperatures up to room temperature. Although they show no superconducting behavior under presently known conditions, they can be grown as epitaxial heterostructures with superconductors.

The transport properties of $La_{0.67}Ca_{0.33}MnO_3$ were studied over a wide range of temperatures above the Curie temperature of 262 K and fit to the Emin-Holstein model of adiabatic small polaron hopping using quite reasonable parameters.[3] In the final year the conductivity measurements from 300 K to 1200 K of $La_cCa_{1-c}MnO_3$ thin films, with doping from $c = 0$ to $c = 1$, show that the entire doping range fits the adiabatic small polaron model $\sigma = (A/T)\exp(-E_a/kT)$. Furthermore the c dependence of A explicitly shows the effects of on-site coulomb repulsion, i.e. a polaron cannot hop into an occupied site. Instead of increasing monotonically as more carriers are introduced, A starts to decrease at $c = 0.8$ and is reduced to almost zero when the lattice is full.[4] The approach to zero of A as c approaches 1 shows that the strong on-site coulomb interaction results in Mott-Hubbard-like insulator behavior.

References

1. Q.Y. Ma. P. Dosanij, J. Carolan, and W. Hardy, Extended Abstracts 4th Int. Superconductive Electronics Conf., ISEC 1993, Aug. 11-14, Boulder Co., and private communication.

2. Private Communication with Dr. L. King at Conductus.

3. D.C. Worledge, G. Jeffrey Snyder, M.R. Beasley, and T.H. Geballe, "Anneal-Tunable Curie Temperature and Transport of $La_{0.67}Ca_{0.33}MnO_3$" J. Appl. Phys 80, 5158-5161 (November 1, 1996).

4. D.C. Worledge, L. Mieville, and T.H. Geballe, "On-site Coulomb Repulsion in the Small Polaron System $La_cCa_{1-c}MnO_3$," (in press) *Phys. Rev. Lett*.

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Publications:

1. D.C. Worledge, G. Jeffrey Snyder, M.R. Beasley, and T.H. Geballe, "Anneal-Tunable Curie Temperature and Transport of $La_{0.67}Ca_{0.33}MnO_3$" J. Appl. Phys 80, 5158-5161 (November 1, 1996).

2. D.C. Worledge, L. Mieville, and T.H. Geballe, "On-site Coulomb Repulsion in the Small Polaron System $La_cCa_{1-c}MnO_3$," (in press) *Phys. Rev. Lett*.

Meetings:

Daniel Worledge presented a paper at American Physical Society March Meeting, Kansas City, MO., March 17-21, 1997.

Transitions:

None currently

New discoveries, inventions, or patent disclosures:

None

Honors/Awards:

D. Worledge, NSF Fellowship
Jeffrey Snyder graduated with a PhD in Applied Physics and is currently employed at the Jet Propulsion Laboratory, Pasadena, California (available at University Microfiche, Ann Arbor, MI).